Determination of the Origin and Paleoseismologic History of southern Sikeston Ridge, New Madrid Seismic Zone, Missouri

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by
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INTRODUCTION

William Lettis & Associates, Inc. (WLA) is conducting a geomorphic and paleoseismic analyses of southern Sikeston Ridge, in the northern part of the Lake County Uplift (LCU). Sikeston Ridge is a 5-to 10-m-high, 50-km-long, linear ridge that extends from New Madrid, Missouri, north to just beyond Sikeston (Figure 1). Its southern end intersects the northern zones of contemporaneous seismicity associated with the New Madrid Seismic Zone (NMSZ), as well as the Holocene-active LCU. Until recently, the ridge was considered a Pleistocene erosional remnant formed by an easterly migrating Mississippi River channel (Fisk, 1944; Saucier, 1996). However, seismic reflection data suggest that the western (Street, unpublished, 1999; Sexton, 1992) and eastern margins (Sexton, 1992) of the ridge partly are coincident with faults having possible Quaternary displacement. Also, indirect geomorphic evidence (Boyd and Schumm, 1995), recent exploratory trenching (Baldwin et al., 1998), and ground penetrating radar data (Liu and Li, unpublished, 1999) permit the interpretation of late Pleistocene to Holocene surface deformation coincident with the western margin of the ridge (Figure 2). Because of diffused microseismicity along the western margin of the ridge, and a historical earthquake of M5 (Rhea et al., 1995) near the town of Matthews and Sikeston, we find that the ridge may be a product of episodic coseismic uplift during earthquakes along recently activated, steeply dipping reverse faults. Thus, faults bordering Sikeston Ridge may represent previously unrecognized seismic sources within or adjacent to the NMSZ. If so, the earthquake characteristics of these faults are unknown, including the timing and recurrence of late Quaternary earthquakes, the late Quaternary slip rate on faults, and the role that these ridge-margin faults play in present-day tectonic deformation of the NMSZ.

This study represents a two-year investigation to evaluate the potential seismic hazards of southern Sikeston Ridge located in the northern NMSZ. The first year of research included an initial assessment of the western margin of Sikeston Ridge to: 1) assess potential seismic hazards related to possible Quaternary faults along the western margin of Sikeston Ridge; 2) determine the number and timing of late Holocene large earthquakes (if any); and 3) estimate slip rate(s) for the ridge-margin fault(s). To achieve these objectives, we performed the following tasks during the first

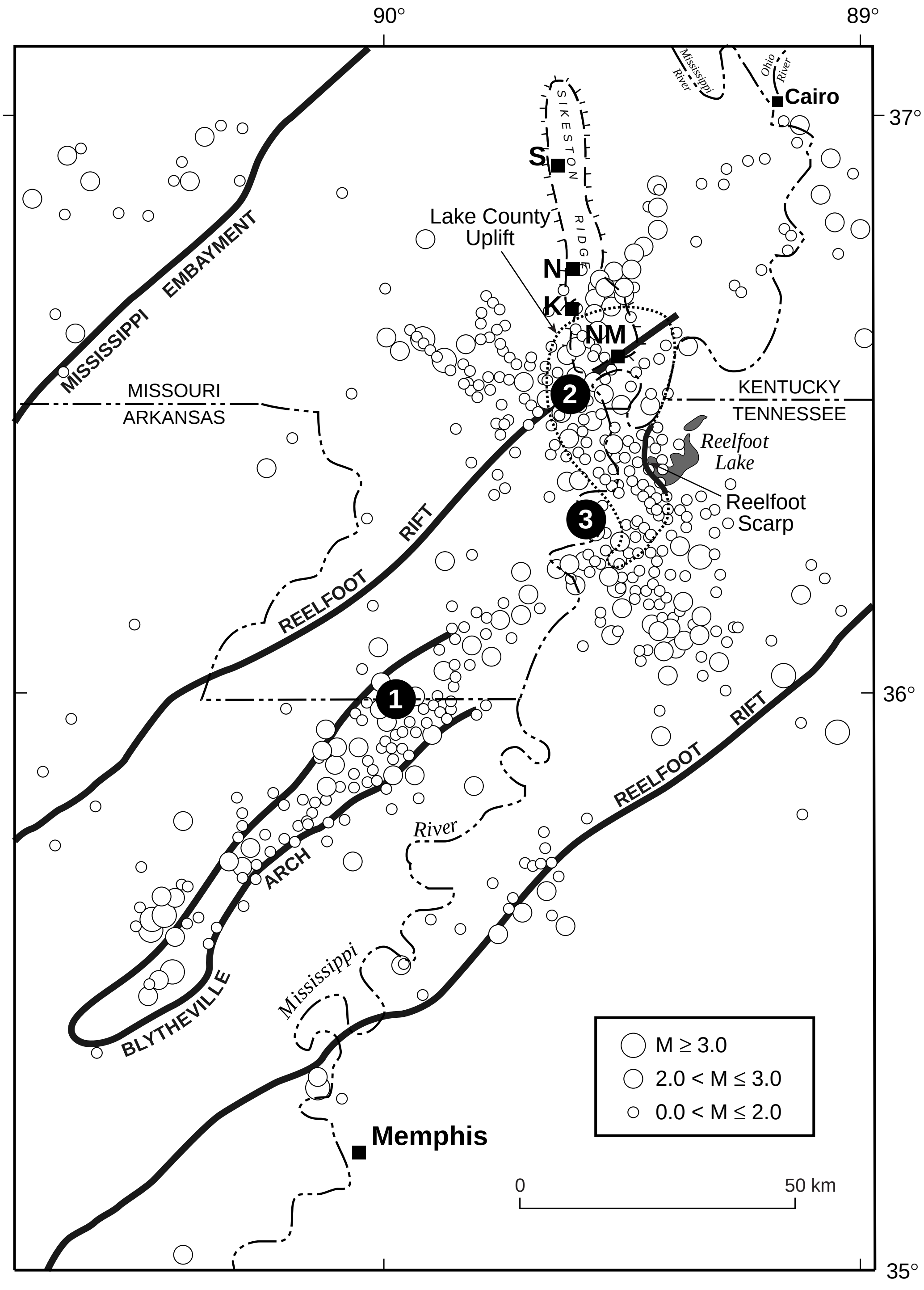

Figure 1. Map showing regional tectonic setting and historical seismicity of the New Madrid seismic zone. S=Sikeston; NM=New Madrid; K=Kewanee, N=Noxall. Solid circles are approximate epicenters for earthquakes on (1) December 16, 1811, (2) February 7, 1812 and (3) January 23, 1812 [After Nuttli, 1973; Johnston and Schweig, 1996].

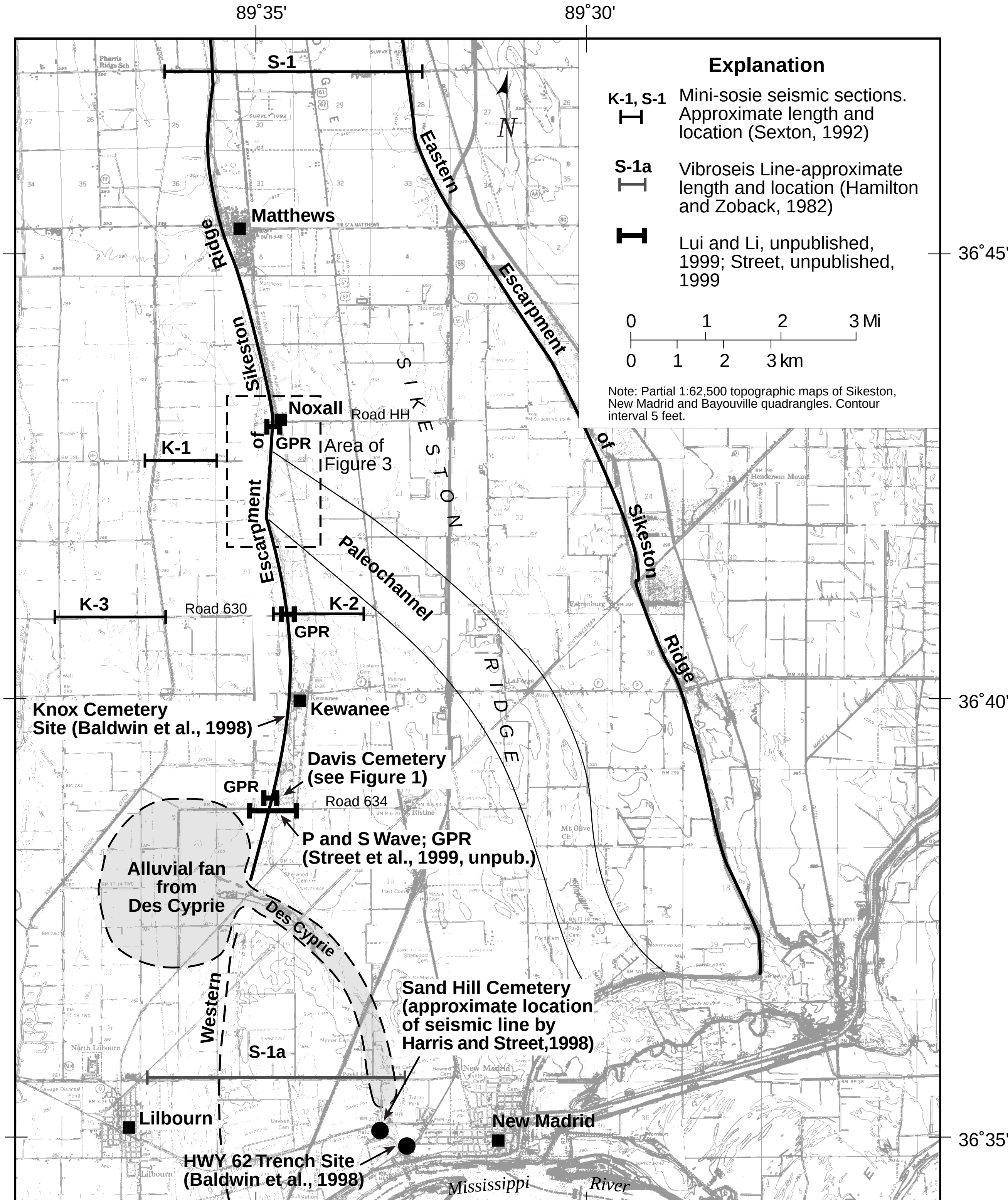

Figure 2. Topographic map showing Davis Cemetery site, previous paleoseismic studies, and seismic reflection surveys of Sexton (1992), Hamilton and Zoback (1982), Harris and Street (1998), and recent GPR surveys (Lui and Li, unpublished, 1999; Street et al., unpublished, 1999)

year: 1) prepared a preliminary Quaternary geologic/geomorphic map of southern Sikeston Ridge using large and small-scale aerial photography and field reconnaissance; 2) drilled six boreholes across the western topographic escarpment to assess an apparent offset paleochannel; 3) excavated three paleoseismic trenches across the western topographic escarpment and submitted charcoal samples for radiometric analyses; 4) surveyed three topographic profiles across the western margin; 5) collaborated with Dr. Lanbu Liu of University of Connecticut on four ground penetrating radar (GPR) surveys, and Dr. Ron Street of University of Kentucky on a P-and S-wave survey, as well as a GPR survey; all of which were conducted along the western margin of Sikeston Ridge; and 6) presented our initial findings as part of a NMSZ Field Trip for the Eastern Section of the Seismological Society of America (SSA) Meeting in Memphis, Tennessee.

RESULTS

To identify and characterize potentially active structures along the western margin of Sikeston Ridge, we conducted preliminary geologic and geomorphic mapping of the southern part of Sikeston Ridge between Sikeston and New Madrid. We produced annotated maps that are being used to test the hypothesis that some of the topographic relief between Sikeston Ridge and areas east and west of the ridge is in part due to geologic uplift along ridge-margin faults. Geomorphic lineaments and features were identified initially through the interpretation of aerial photography of the study area. Photographs reviewed included 1:40,000-scale U.S. Geological Survey infrared photography, and black and white 1:24,000-scale photography from the U.S. Department of Agriculture. Currently, the geomorphic features are being compiled on parts of four 1:24,000-scale U.S. Geological Survey 7.5-minute quadrangle maps (Sikeston South, Kewanee, New Madrid, and Henderson Mound).

On the basis of our geomorphic mapping and reconnaissance-level field studies, we identified several paleoseismic trench sites, including a prominent southeast-trending paleochannel, near Noxall, that appears truncated by the western margin of Sikeston Ridge (Figure 2). To evaluate this feature further, we drilled six boreholes (SR99-1 to SR99-6) to depths as much as 17 m using standard hollow-stem auger and mud-rotary drilling techniques. Boreholes SR99-1, SR99-3 and SR99-4 were drilled along a north-south transect east of the ridge margin to determine the depth and geometry of the paleochannel's northern margin. Boreholes SR99-2, SR99-5 and SR99-6 were drilled along a north-south transect, slightly west of the western topographic escarpment to assess the presence or absence of the paleochannel margin west of Sikeston Ridge. The boreholes exposed bedded, poorly to well sorted sand, silty sand, sandy gravel with stringers of clay and lignite both east and west of the western margin of Sikeston Ridge. The borehole data permit the interpretation that the stratigraphy exhibits an apparent west side down vertical component of separation, however only with a poor degree of confidence. We, therefore, identified other possible paleoseismic trenching sites along the ridge margin on the basis of geomorphology and preliminary geophysical survey data (Street, unpublished, 1999).

The drilling program provided little equivocal evidence to support the presence or absence of tectonic deformation along the western margin of Sikeston Ridge, therefore, we collaborated with Dr. Ron Street of the University of Kentucky who was finalizing a preliminary geophysical evaluation of the western and eastern margins of Sikeston Ridge. Preliminary interpretation (Street, unpublished, 1999) of P-wave and Shear-wave geophysical survey data along New Madrid County Road 634 identified a distinct marker bed at about 65 m in depth that is believed to be an Eocene gravel deposit. This marker unit appears to be deformed and truncated near the western margin of Sikeston Ridge (Street, unpublished, 1999). Subsequent GPR data collected along the surface projection of the deformed Eocene gravel on Road 634 suggest a 100-m-wide flower structure with multiple Quaternary faults coincident with the ridge margin (Harris and Street, unpublished, 1999). On the basis of the apparent deformation inferred from the deep and shallow geophysical surveys, we excavated three trenches at Davis Cemetery located directly north of Road 634 to obtain data on the style and timing of surficial deformation, and amount of vertical displacement.

At Davis Cemetery, three trenches (DC-1 to DC-3) totaling about 80 m in length were excavated to as much as 2.5 m deep (Figure 2). Surficial deposits encountered in trenches DC-1 to DC-3 consisted primarily of late Pleistocene to early Holocene fluvial deposits (“valley train deposits of Sikeston Ridge”) overlain by Holocene colluvial and fluvial deposits similar to those exposed at Knox Cemetery (Baldwin et al., 1998). The late Pleistocene to early Holocene valley train material includes well-stratified, unconsolidated silt, sand, and discontinuous clay lenses that provide excellent marker beds to observe the effects of surface fault rupture and/or subtle deformation.

Minor faulting was exposed in trenches DC-1 and DC-2, with the exception of a 7-m-wide graben present near the crest of the western topographic escarpment in trench DC-1. The shear planes strike north to north-northeast, and dip both east and west between 54 to 59 degrees forming conjugate fault pairs. The graben is bordered by fault strands that extend upward to within about 0.5 m of the ground surface, although there is no geomorphic expression of the graben in the present-day topography. The total amount of vertical offset across the late Pleistocene to early Holocene valley train deposits is about 15 m. The faulting exposed in trenches DC-1 and DC-2 is consistent with the deformation exposed in a trench at Knox Cemetery (Baldwin et al., 1998) and the GPR survey conducted along Road 634. We currently are analyzing the preliminary trench, radiometric, GPR and geophysical survey data. Collectively the data support late Quaternary deformation (either primary or secondary) within the northernmost part of the LCU and along the western margin of Sikeston Ridge.

Lastly, we also surveyed three topographic profiles along the western margin of Sikeston Ridge, where recent GPR surveys had been conducted by Liu and Li (unpublished, 1999). The purpose of the profiles was to provide elevation control for the GPR surveys and to correlate deformation observed in the surveys with the western topographic escarpment. The topographic and GPR profiles were conducted along east-west transects on Roads HH, 630 and 634 (Figure 2). The Road HH survey in Noxall is about 500 m north of our drilling investigation; Road 630 is along the location of a Minie-sosie seismic profile (Line K-2) shot by Sexton (1992) (Figure 2); and Road 634 is located directly south of Davis Cemetery where P-and S-wave geophysical surveys, as well as a shallow GPR survey were conducted (Street, unpublished, 1999; Harris and Street, unpublished, 1999). The initial findings of the GPR and topographic surveys along Roads HH, 630 and 634 are pending data processing by Dr. Liu. Field data suggest that all three sites exhibit shallow surface faulting at or near the ridge margin (Liu and Li, personal communication).

NON-TECHNICAL SUMMARY

This study represents a two-year investigation to evaluate the potential seismic hazards of southern Sikeston Ridge located in the northern NMSZ. Through geologic and geomorphic mapping, drilling, paleoseismic trenching, and geophysical surveys, we are evaluating the origin of southern Sikeston Ridge, and the activity of the western ridge-bounding faults. On the basis of geologic mapping, this study will also identify other possible seismogenic features associated with southern Sikeston Ridge and the northern LCU.

REPORTS PUBLISHED

No reports have been published yet as a result of this study. However, we presented the preliminary findings of our geomorphic and paleoseismic investigation as part of a NMSZ Field Trip associated with the Eastern Section of the Seismological Society of America (SSA), October 16-17,1999 Meeting in Memphis, Tennessee (Van Arsdale et al., 1999). The SSA field trip allowed us the opportunity to have a formal review of our preliminary geomorphic mapping and interpretation of trench and on-site GPR data with active researchers in the NMSZ.

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